LLNL Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.7: Well Closure—Revision: 3

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1.0 PURPOSE

The purpose of this SOP is to describe methods for decommissioning wells *in-situ* by perforation and subsequent grout injection or by the removal of construction materials followed by grout injection. The well closure technique is commonly dependent on the nature and type of well completion materials. *In-situ* well closure involves casing perforation and is used when metal casing cannot be easily removed. Well closure by removal of casing is employed for any well material where it is practical to drill the well out using hollow stem augers or a rotary technique with a drill bit. This latter method is primarily used for wells constructed completely with polyvinyl chloride (PVC) casing. The Drilling Supervisor (DS) will determine if a combination of closure methods is required for wells with one or more conductor casings, which are usually constructed of steel. Local regulatory agencies will be consulted if, for any reason, a well cannot be decommissioned solely by the methods discussed within this SOP.

2.0 APPLICABILITY

This procedure is applicable to wells that are to be permanently sealed, based on the present or future potential for a well to act as a conduit for the vertical migration of hazardous materials in ground water. Other characteristics may also provide cause for sealing a well. A well meeting any of the criteria listed below should be considered for closure:

A. Multiple screened intervals or a single screened interval over several water-bearing zones.

B. Lack of annular seal.

C. Any well suspected of allowing migration of contaminants to non-contaminated zones.

D. Threatened water supply wells located at or near an existing plume margin.

E. Unknown or undocumented well construction details.

F. Improper well construction or damaged well.

G. Abandoned well (DWR, 1981).

3.0 REFERENCES

3.1 Department of Water Resources (1981) *Water Well Standards: State of California,* California Resources Agency, Bulletin 74-81.

3.2 LLNL (2000a), *Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300*, Environmental Protection Department, Lawrence Livermore National Laboratory (UCRL-21172 Rev. 3).

3.3 LLNL (2000b), *Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Livermore Site*, Environmental Protection Department, Lawrence Livermore National Laboratory (UCRL-21174 Rev. 2).

4.0 DEFINITIONS

See SOP glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader (DL)

The DL's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and to provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeology Group Leader (HGL)

The HGL ensures that the proper procedures are followed for all well abandonment activities.

5.3 Drilling Supervisor (DS)

The DS schedules overall drilling-related activities and coordinates the schedules for drilling contractors and obtains necessary equipment.

5.4 Drilling Coordinator (DC)

The DC provides the interface between the DS, Subproject Leader (SL), Hydrogeologist (HG), and the field personnel. The DC is responsible for notifying Building Coordinators, Site Planning Division, and LLNL Gardeners, to coordinate any necessary surveys (utilities, biological, and archaeological) prior to drilling, and the daily monitoring of the progress of all drilling-related activities.

5.5 Drilling Geologist (DG)

The DG is responsible for conducting and documenting drilling and well abandonment, following operational safety procedures (OSPs), SOPs, and the well abandonment work plan, and to immediately inform the DC and SL of any nonconformances and unforeseen circumstances that require resolution.

5.6 Subproject Leader (SL)

The SL is responsible for the overall investigation, planning, assessment, and remediation within a subproject area.

5.7 Hydrogeologist (HG)

The HG is responsible for assisting the SL in determining wells that may require abandonment due to meeting any of the requirements in Section 2.0 and in assisting the SL and DC in determining the best strategy for successful and proper abandonment.

6.0 PROCEDURES

The abandonment process should minimally alter the geologic medium surrounding the well to be abandoned. It is essential that the process does not introduce hazardous or foreign substances into the well or borehole, create conduits that facilitate the spread of existing contaminants, or does not adequately remove well materials and seal the resulting borehole.

6.1 Office Preparation

Review procedures outlined in this SOP and in SOP 4.1, "General Instructions for Field Personnel," Section 6.2, the Site Safety Plans (SSPs) (LLNL, 2000a,b), and applicable Integration Work Sheets (IWSs) prior to performing field work.

6.1.1 *In-Situ* Closure

A. Obtain all pertinent records such as drillers' logs, water level measurements, perforated intervals, and any required permits or access agreements.

B. Obtain necessary permits for off-site wells.

C. Obtain Mills Knife perforation equipment and air compressor, making sure the correct shoes are available for each casing diameter.

D. Determine the depth intervals of clay-rich zones greater than 5-ft thick from geophysical logs (gamma ray), drillers' logs, or other well logs.

E. Determine zones to perforate from evaluation of logs, taking into account the zones that had been perforated previously.

F. Determine or estimate the depth of any nearby ground water contaminant plumes for each well location.

G. Coordinate schedule/actions with DC.

6.1.2 Well Removal

A. Obtain all pertinent records such as drillers' logs, water-level measurements, perforated intervals, and any required permits or access agreements. Conduct a downhole camera survey if additional information is necessary.

B. Coordinate schedule/actions with DC.

6.2 Field Preparation

Follow procedures outlined in this SOP and in SOP 4.1, Section 6.2 and the SSPs (LLNL, 2000a,b), and applicable IWSs when performing field work.

6.2.1 Remove pump and piping from the well.

6.2.2 Confirm that there are no obstructions in the well. For deep wells (more than 100 ft deep), run video logs and geophysical logs as needed to ascertain casing condition, presence and nature of existing perforations, and location of high and low permeability intervals.

6.2.3 Check drill rig access to the well.

6.2.4 Remove existing vault or stovepipe and concrete pad, if necessary.

6.3 Operation

Follow procedures outlined in this SOP and in SOP 4.1, Section 6.2, the SSPs, and applicable IWSs when performing field work.

6.3.1 Document the following for all wells**:**

A. Well name.

B. Sounded depth of well.

C. Water level, if applicable.

D. Casing size and materials.

E. Drilling company and driller.

F. Drilling Supervisor and Drilling Geologist.

G. Date/time for start and completion of closure.

H. Closure method(s) and materials used.

I. If no survey data exists, prepare a detailed site map accurately showing the well in relation to permanent features.

6.3.2. *In-Situ* Closure

A. Select intervals to perforate from the drillers' log, geophysical log, and video log if available. Determine if previously perforated zones should be re-perforated due to possible compromise of casing.

B. Operate Mills Knife perforator to cut six 1-in. slots per foot, with four rows at 90 degrees from one another.

C. Perforate all previously unperforated low-permeability zones greater than 5-ft thick within the plume (if a plume exists), and selected low-permeability zones greater than 5-ft thick between the static water level down to 20 ft below the estimated base of plume (if existing) or to 5 ft below the saturated zone.

D. If casing conditions permit, perforate all low-permeability zones (thicker than 5 ft) that occur between the estimated plume base (if existing) and total depth.

E. Calculate the minimum volume of grout required to seal the well.

F. Pump the grout from the bottom of the well to the surface through a tremie pipe using a cement mixture (2 lb of commercial bentonite powder and approximately 6.5 gal of water added per 94-lb bag of cement).

G. When the grout reaches the surface, verify that the volume of grout used is equal or greater than the calculated volume in Step E.

H. Apply pressure from the surface using either an air-actuated packer or a welded cap (at the surface). Apply at least 50 pounds per square inch of pressure for approximately 1 to 2 hr until stable.

I. The following day, seal the surface by perforating a zone from 2 to 20 ft and top off to the surface with a final stage of grout.

6.3.3 Well Removal

A. Drill out the casing using hollow stem augers or a drill bit, as determined by the driller. For both methods, the drill bit should be slightly larger than the diameter of the original well borehole to remove all of the filter pack.

B. To the extent feasible, ensure that all of the casing has been removed. When using a drill bit, frequently check and document that pieces of casing are in the cuttings. Also note any decrease in drill rig chattering, which may indicate that the bit has deflected off the casing.

C. Once the well and sandpack are completely removed, an open borehole remains. Calculate the minimum volume of grout required to fill the open borehole.

D. Pump the grout from the bottom of the borehole to the surface through a tremie pipe (grouting with a tremie pipe is not required for dry boreholes that do not exceed 30-ft depth). Place the tremie pipe 5 to 10 ft off the bottom of the borehole and pump a cement mixture (2 lb of commercial bentonite powder mixed with approximately 6.5 gal of water per 94-lb bag of cement)

through this pipe until undiluted grout flows from the borehole at the ground surface. The tremie pipe should be withdrawn gradually during this process.

E. When the grout reaches the surface, verify that the volume of grout used is equal or greater than the calculated volume in Step C.

F. While waiting for the grout to set, cover and barricade the borehole to prevent introduction of foreign material and to protect the public.

G. After the grout has set (about 72 hr), fill any depression in the grout due to settling. Use a grout mixture similar to that described above.

6.4 Post Operation

6.4.1 Perform post-work activities described in SOP 4.1, Section 6.4, including equipment decontamination, proper waste disposal, equipment inventory, documentation review, and field form and logbook delivery to the SC or Data Management Team (DMT).

6.4.2 The DC should ensure that all field forms are maintained and submitted. The DG's report should give a complete description of work performed, number of hours on the job, shutdown due to breakdown, length of casing removed/perforated, materials used, and other pertinent data.

7.0 QUALITY ASSURANCE RECORDS

7.1 Field Forms

7.2 Logbooks

8.0 ATTACHMENTS

Not applicable.